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ISO/TC 183/WG 10
DETERMINATION OF PRECISION OF ANALYTICAL PROCEDURES BY INTERNATIONAL TRIALS - TESTS FOR OUTLIERS

R. Sutarno and W.S. Bowman
Extractive Metallurgy Laboratory

April 1986

For presentation at the ISO/TC 183 meeting to be held in Sydney, Australia, April 27 to May 3, 1986 and for submission to the Secretariat of ISO/TC 183.

Project - 30.69.02
Analytical Methodology

41 pp

MINERAL SCIENCES LABORATORIES
DIVISION REPORT MSL 86-52 (IR)

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MICROMEDIA

ISO/TC 183 (WG10-6)
April 1986

ISO/TC 183/WG 10
DETERMINATION OF PRECISION OF ANALYTICAL PROCEDURES BY INTERNATIONAL TRIALS - TESTS FOR OUTLIERS

by

R. Sutarno* and W.S. Bowman**

SUMMARY

Statistical methods for identification of suspected outliers by Cochran's test (due to precision) and by Grubbs' and Dixon's tests (due to deviation from the mean) have been applied to the results of international tests conducted by ISO/TC 183 (International Organization for Standardization Technical Committee 183 - Copper, Lead and Zinc Ores and Concentrates) for the estimation of precision of analytical methods for the determination of Ag, Au and Cu in copper concentrates. These international tests involve 38 samples, 738 laboratory-sets and 2194 analytical results.

The results of this evaluation show that: (1) a 5% level of significance is more suitable than a 1% level of significance for both the Cochran-Dixon combination of tests, and (2) there is virtually no difference in the results of tests for outliers using a Cochran-Dixon combination and a Cochran-Grubbs combination for both levels of significance.

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*Research Scientist and **Technologist, Physical Chemistry Section, Extractive Metallurgy Laboratory, Mineral Sciences Laboratories, CANMET, Energy, Mines and Resources Canada, Ottawa, Ontario, K1A 0G1.

ISO/CT 183 (GT10-6)
Avril 1986

ISO/CT 183/GT 10
DÉTERMINATION DE LA PRÉCISION DE LA MÉTHODE ANALYTIQUE AU MOYEN D'ESSAIS MENÉS À L'ÉCHELLE INTERNATIONALE - ESSAIS PORTANT SUR LES ABERRANCES

par

R. Sutarno* et W.S. Bowman**

RÉSUMÉ

Les méthodes statistiques utilisées pour identifier les aberrances présumées par l'essai de Dixon (en raison de sa précision) et les essais de Grubbs et Dixon (en raison de l'écart moyen) ont été appliquées aux résultats des essais menés à l'échelle internationale par ISO/GT 183 (Comité technique 183 - cuivre, plomb, minerai et concentrés de zinc, Organisation internationale de normalisation) en vue d'évaluer la précision des méthodes analytiques utilisées pour déterminer la teneur en Ag, As et Cu des concentrés de cuivre. Ces essais effectués à l'échelle internationale ont porté sur 38 échantillons, 2 194 résultats analytiques et exigé la participation de 738 groupes-laboratoire.

Les résultats de cette évaluation indiquent que: (1) un niveau de signification de 5 % est plus approprié qu'un niveau de signification de 1 % pour l'ensemble des essais Cochran-Dixon et (2) il n'existe pratiquement aucune différence entre les deux niveaux de signification des essais combinés Cochran-Dixon ou des essais Cochran-Grubbs d'après les résultats des essais portant sur les aberrances.

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*Chercheur scientifique et **Technologue, Section de la chimie physique, Laboratoire de métallurgie extractive, Laboratoires des sciences minérales, CANMET, Énergie, Mines et Ressources Canada, Ottawa (Ontario) K1A 0G1.

INTRODUCTION

During the period of 1984-1986, ISO/TC 183 (International Organization for Standardization, Technical Committee 183 - Copper, Lead and Zinc Ores and Concentrates) has completed four international tests on methods for (a) determination of Au and Ag in copper concentrates by fire assay (WG 1A), (b) determination of Ag in copper concentrates by fire assay-AAS (WG 2A), (c) determination of Cu in copper concentrates by titrimitric method and (d) determination of Cu in copper concentrates by electrogravimetric method.

The results of these tests were evaluated statistically to obtain the preliminary estimates of precision of the analytical methods. The procedure used for this evaluation is described in document ISO/TC 102/TCR 5 (1). This procedure, which was developed by ISO/TC 102/SC 2 (ISO Technical Committee 102 - Iron Ores - Sub-committee 2 - Chemical Analysis), uses the same principle as ISO 5725 (2) modified to suit the special requirements for mineral analysis.

One of the modifications is in the procedure for testing for outliers. ISO 5725 uses both Cochran's and Dixon's tests at 1% level of significance, while ISO/TC 102/TCR 5 uses the same tests, except at 5% level.

In this work, the data were processed using both levels of significance as well as using Grubbs' test in lieu of Dixon's. The results of these tests for outliers are compared with "chemical common sense", subjectively applied by the authors.

EXPERIMENTAL DESIGN

The experimental design used in these international tests was a the uniform level design(2). Samples of copper concentrates of h different levels were sent to Ko laboratories in various countries. They were requested to perform analyses on each sample in triplicate. The value of h was 6 for WG 1A and WG 2A (Au and Ag) and 5 for WG 3A and WG 4A (Cu). The number of participating laboratories, Ko, varies from 15 to 25. Ko is the number of laboratories that reported analytical results to the working group's convener. Most of these laboratories complied with the convener's request to analyse each sample in triplicate. These data were then forwarded to ISO/TC 183/WG 10 for evaluation.

STATISTICAL EVALUATION

The analytical data resulting from these trials are presented in references 2,3,4 and 5. These data were statistically evaluated by the procedure that is illustrated schematically in Figure 1(1). The sequence of the tests for outliers was as follows:

(1) The data were plotted in order to provide visual observation of the relative position of each laboratory's results.

(2) The data were subjected to Bartlett's test, at 5% level of significance, for homogeneity of within-laboratory variance.

(3) If Bartlett's test showed significance, then Cochran's test was applied to identify the suspected outliers.

(4) At this stage the suspected outliers were marked. All the data (including the Cochran's suspects) were subjected to Dixon's test (two sided test).

(5) Cochran's and Dixon's tests were performed at both 1% and 5% levels of significance.

(6) These evaluations were repeated using Grubbs' (6) test in place of Dixon's test.

RESULTS AND DISCUSSION

The main objectives of this work are to see which of these tests for outliers and levels of significance are more suitable for ISO/TC 183 work. The criterion used to judge this suitability is "chemical common sense" as applied by the authors i.e., based on intuition the authors reject certain data and compare this rejection with the results of the statistical tests.

(1) Effect of level of significance

The results of the statistical tests using the Cochran-Dixon combination for both 1% and 5% levels of significance are listed in Table 1. There is inconsistency in the identification of participating laboratories by different working groups. WG 1A and WG 3A identified their participating laboratories by number only, while WG 2A and WG 4A used the country identification as well. The number of outliers and the ratio of between-laboratories to within-laboratory standard deviation sL/sr, are listed in Table 2

and summarized in Table 3. The stragglers (the results that are suspects at 5% level of significance and not at 1% level) are compared with the authors' intuition based on observation of Figures 2. The results of this comparison are summarized in Table 4. Table 5 lists the sample means, repeatability and permissible tolerance obtained by processing the data using Cochran-Dixon combination at 5% and 1% levels of significance.

Table 3 shows that for 5% level of significance, the number of suspected outliers is about 7% of the total number of data. For 1% level of significance, the number of suspected outliers is about 4%. This difference of about 3% between the two levels of significance is probably reasonable.

Table 4, on the other hand, shows that a number of those stragglers are found to be suspects according to the authors' intuition. Table 5 shows that in some cases the level of significance could alter the value of the estimated precision. The magnitude of this effect depends on the particular position of the particular straggler.

(2) Comparison between Dixon's and Grubbs' tests

The comparison of suspected outliers as identified by Grubbs' and Dixon's tests are listed in Table 6 for 1% level of significance and Table 7 for 5% level of significance. These two tables show that there are very few differences between the results of these two tests. These differences are listed in Table 7. For 1% level of significance, the Grubbs' test seems to be slightly more sensitive; at 5% level, however, the difference is virtually nonexistent.

CONCLUSION

From the above discussion, based on the present data, one could conclude that for testing possible outliers:

(1) Statistically, there is no clear choice between the use of 5% and 1% levels of significance for the Cochran-Dixon combination; the appropriate choice should made on the basis of chemical (or other technical) considerations.

(2) There is little difference between the results of Grubbs' test and Dixon's test when the are used in combination with Cochran's test.

REFERENCES

1. "Procedure for statistical evaluation of analytical data resulting from international tests",ISO/TC 102/TCR 5,1985-06-11

2. "ISO/TC 183/WG 2A Determination of silver in copper concentrates- Statistical evaluation of international test data 1984-1986", R. Sutarno and W.S. Bowman, ISO/TC 183/WG 2A(WG10-2), January 1986; Division Report MSL 86-6(IR); CANMET, Energy, Mines and Resources Canada; 1986.

3. "ISO/TC 183/WG 3A Determination of copper in copper concentrates - Titrimetric methods - Statistical evaluation of international test data 1984-1986", R. Sutarno and W.S. Bowman, ISO/TC 183/WG 3A(WG10-3), January 1986; Division Report MSL 86-5 (IR); CANMET, Energy, Mines and Resources Canada; 1986.

4. "ISO/TC 183/WG 4A Determination of copper in copper concentrates - Electrogravimetric methods - Statistical evaluation of international test data 1984-1986", R. Sutarno and W.S. Bowman, ISO/TC 183/WG 4A(WG10-4), February 1986; Division Report MSL 86-30(IR); CANMET, Energy, Mines and Resources Canada; 1986.

5. "ISO/TC 183/WG 1A Determination of gold and silver in copper concentrates - Fire assay method - Statistical evaluation of international test data 1984-1986", R. Sutarno and W.S.Bowman, ISO/TC 183/WG 1A(WG10-5), February 1986; Division Report MSL 86-39(IR); CANMET, Energy, Mines and Resources Canada; 1986.

6. "Standard practice for dealing with outlying observations", ASTM Standard: E 178-80.

Table 1

ISO/TC 183 Au, Ag and Cu in Copper Concentrates
List of Outliers

WG	Element	Sample	Cochran		Dixon	
			5%	1%	5%	1%
WG 1A	Au	85-1	-	-	-	-
	Au	85-2	LAB 2 LAB 9	LAB 2 LAB 9	LAB13	-
	Au	85-3	LAB30	LAB30	-	-
	Au	85-4	LAB30	LAB30	LAB32	-
	Au	85-5	-	-	-	-
	Au	85-11	LAB30	LAB30	-	-
	Ag	85-5	-*	-	-	-
	Ag	85-1	LAB 2 LAB 3	- -	-	-
	Ag	85-4	LAB 7 LAB 9	LAB 9 -	-	-
	Ag	85-2	LAB14	LAB14	LAB 8	-
	Ag	85-3	-	-	-	-
	Ag	85-11	LAB 8	-	-	-
WG 2A	Ag	85-1	-	-	-	-
	Ag	85-2	AU 2 AU 3 CHN 2 CHN 3	AU 3 CHN 2 CHN 3 -	AU 3	AU 3
	Ag	85-3	-	-	-	-
	Ag	85-4	AU 2	AU 2	-	-
	Ag	85-5	-	-	AU 2	-
	Ag	85-11	-	-	AU 3	-

Table 1 (cont'd)

ISO/TC 183 Au, Ag and Cu in Copper Concentrates
List of Outliers

WG	Element	Sample	Cochran		Dixon	
			5%	1%	5%	1%
WG 3A Long	Cu	85-6	LAB 4	LAB 4	-	-
	Cu	85-7	LAB 5	LAB 5	-	-
	Cu	85-8	-	-	LAB 3 LAB26	LAB 3 LAB26
	Cu	85-9	LAB17 LAB24 LAB26	LAB17 - -	LAB26	-
	Cu	85-10A	LAB24 LAB26	- -	-	-
WG 3A Short	Cu	85-6	LAB 4 LAB19 LAB24	LAB19 LAB24 -	LAB19 LAB24	LAB19 -
	Cu	85-7	-	-	-	-
	Cu	85-8	-	-	LAB26	LAB26
	Cu	85-9	-	-	-	-
	Cu	85-10A	-	-	-	-
WG 4A Sul.	Cu	85-6	GER 3	GER 3	-	-
	Cu	85-7	-	-	-	-
	Cu	85-8	CND 3	CND 3	-	-
	Cu	85-9	GER 3	GER 3	-	-
	Cu	85-10A	-	-	-	-

Table 1 (Cont'd)

ISO/TC 183 Au, Ag and Cu in Copper Concentrates
List of Outliers

WG	Element	Sample	Cochran		Dixon	
			5%	1%	5%	1%
WG 4A Hyd.	Cu	85-6	CND 3 CND 4 GER 4 GER 5 UK 1	CND 3 CND 4 GER 5 - -	CND 4 GER 5	CND 4 -
	Cu	85-7	AU 1 GER 5 JP 2 UK 1	UK 1 - - -	CND 4	CND 4
	Cu	85-8	CND 3 CND 4 GER 4	- - -	-	-
	Cu	85-9	CND 3	-	-	-
	Cu	85-10A	CND 4	CND 4	CND 4	CND 4

* One laboratory result for WG 1A Ag sample 85-5 was rejected because the laboratory reported only one result (see Table 2).

Table 2

ISO/TC 183 Au, Ag and Cu in Copper Concentrates
Number of Outliers
(Cochran and Dixon)

WG	Element	Sample	Ko	Ks		No.	Ns		sL/sr	
				5%	1%		5%	1%	5%	1%
WG 1A	Au	85-1	20	-	-	60	-	-	1.04	1.04
	Au	85-2	20	3	2	60	9	6	0.89	1.41
	Au	85-3	20	1	1	60	3	3	0.78	0.78
	Au	85-4	20	2	1	60	6	3	1.13	1.62
	Au	85-5	19	-	-	56	-	-	0.69	0.69
	Au	85-11	18	1	1	54	3	3	1.98	1.98
	Ag	85-5	16	1	1	45	1	1	1.87	1.87
	Ag	85-1	17	2	-	49	6	-	1.25	1.19
	Ag	85-4	17	2	1	51	6	3	2.30	1.82
	Ag	85-2	17	2	1	51	6	3	1.28	1.64
	Ag	85-3	15	-	-	44	-	-	2.46	2.46
	Ag	85-11	14	1	-	42	3	-	1.28	0.91
WG 2A	Ag	85-1	17	-	-	51	-	-	1.86	1.86
	Ag	85-2	17	4	3	51	12	9	4.40	3.39
	Ag	85-3	15	-	-	45	-	-	2.83	2.83
	Ag	85-4	16	1	1	48	3	3	2.48	2.48
	Ag	85-5	16	-	-	48	-	-	1.76	1.76
	Ag	85-11	15	1	-	45	3	-	1.78	3.18
WG 3A Long	Cu	85-6	25	1	1	74	3	3	3.01	3.01
	Cu	85-7	25	1	1	74	3	3	2.61	2.61
	Cu	85-8	25	2	2	74	5	5	0.81	0.81
	Cu	85-9	25	3	1	74	9	3	3.54	3.11
	Cu	85-10A	21	2	-	62	6	-	2.63	1.91
WG 3A Short	Cu	85-6	26	3	2	77	9	6	2.46	2.13
	Cu	85-7	26	-	-	77	-	-	3.42	3.42
	Cu	85-8	26	1	1	77	3	3	1.43	1.43
	Cu	85-9	26	-	-	77	-	-	3.41	3.41
	Cu	85-10A	22	-	-	66	-	-	2.29	2.29
WG 4A Sul.	Cu	85-6	18	1	1	54	3	3	1.61	1.61
	Cu	85-7	18	-	-	54	-	-	1.55	1.55
	Cu	85-8	18	1	1	53	3	3	1.66	1.66
	Cu	85-9	18	1	1	54	3	3	2.74	2.74
	Cu	85-10A	14	-	-	42	-	-	1.70	1.70
WG 4A Hyd.	Cu	85-6	20	5	3	59	15	9	2.55	1.73
	Cu	85-7	20	5	2	60	15	6	2.11	1.61
	Cu	85-8	20	3	-	60	9	-	1.99	1.43
	Cu	85-9	20	1	-	60	3	-	4.42	3.76
	Cu	85-10A	16	1	1	48	3	3	2.10	2.10

Table 3

ISO/TC 183 Au, Ag and Cu in Copper Concentrates
Summary of the Number of Outliers
(Cochran and Dixon)

	5%	1%
No. of international tests	7	7
No. of sample sets	38	38
No. of laboratory results	738	738
No. of oultlying laboratories	52	29
Percent of outlying laboratories	7.0	3.8
No. of analytical results	2196	2196
No. of outliying results	151	84
Percent of outlying results	6.9	3.8
Average sL/sr ratios	2.1	2.0

Abreviation used in Table 2:

Ko - Number of laboratory sets results
Ks - Number of laboratory sets results that are suspected to be outliers
No. - Total number of analytical results
Ns - Number of analytical results suspected to be outliers

Table 4

ISO/TC 183 Au, Ag and Cu in Copper Concentrates
List of Stragglers

WG	Element	Sample No.	Straggler Lab. Results			
			Cochran	Chem*	Dixon	Chem*
WG 1A	Au	85-2			LAB13	y
	Au	85-4			LAB32	y
	Ag	85-1	LAB 2	y		
			LAB 3	y		
	Ag	85-4	LAB 7	?		
	Ag	85-2			LAB 8	y
	Ag	85-11	LAB 8	y		
WG 2A	Ag	85-2	AU 2	?		
	Ag	85-5			AU 2	y
	Ag	85-11			AU 3	y
WG 3A Long	Cu	85-9	LAB24	?	LAB26	y
			LAB26	?		
	Cu	85-10A	LAB24	?		
			LAB26	?		
WG 3A Short	Cu	85-6	LAB 4	?	LAB24	?
			LAB24			
WG 4A Hyd.	Cu	85-6	GER 4	n	GER 5	y
			UK 1	n		
	Cu	85-7	AU 1	?		
			GER 5	?		
			JP 2	?		
	Cu	85-8	CND 3	?		
			CND 4	y		
			GER 4	y		
	Cu	85-9	CND 3	?		

* Authors intuition based on graphical observation
y - Data would have been rejected based on visual observation
? - It is uncertain that the data would have been rejected based on visual observation
n - Data would be used for farther computation

Table 5

Comparison between the grand means (x), repeatability (r), and permissible tolerance (P), obtained processing the data using 5% and 1% levels of significance.

WG	El	Sample	x(ug/g)		r(ug/g)		P(ug/g)	
			5%	1%	5%	1%	5%	1%
WG 1A	Au	85-1	31.38	31.38	1.59	1.59	2.00	2.00
		85-2	11.30	11.23	0.71	0.72	0.81	1.13
		85-3	76.97	76.97	1.80	1.80	1.90	1.90
		85-4	0.71	0.74	0.33	0.32	0.43	0.57
		85-5	8.70	8.70	0.66	0.66	0.65	0.65
		85-11	0.47	0.47	0.11	0.11	0.22	0.22
WG 1A	Ag	85-5	29.19	29.19	3.09	3.09	6.19	6.19
		85-1	76.67	77.49	4.29	6.57	9.08	6.15
		85-4	140.04	139.92	5.76	6.93	13.57	13.86
		85-2	180.21	179.19	8.22	9.20	16.46	12.01*
		85-3	554.59	554.59	15.93	15.93	40.73	40.74
		85-11	1562.97	1562.09	51.43	64.64	74.68	75.06
WG 2A	Ag	85-5	28.44	28.05	3.73	3.96	6.29	7.51
		85-1	76.97	76.97	5.10	5.10	10.12	10.12
		85-4	141.50	141.50	4.50	4.50	11.62	11.62
		85-2	179.68	179.67	2.44	3.03	10.89	10.49
		85-3	557.03	557.03	9.34	9.34	27.22	27.22
		85-11	1566.01	1556.33	40.40	39.84	77.54	129.84*

* These data show large difference between 5% and 1% levels of significance.

Table 5 (Cont'd)

Comparison between the grand means (x), repeatability (r), and permissible tolerance (P), obtained processing the data using 5% and 1% levels of significance.

WG	El	Sample	x(%)		r(%)		P(%)	
			5%	1%	5%	1%	5%	1%
WG 3A Long	Cu	85-6	19.799	19.799	0.118	0.118	0.365	0.365
		85-7	24.182	24.182	0.159	0.159	0.429	0.429
		85-8	33.328	33.328	0.215	0.215	0.232	0.232
		85-9	50.416	50.454	0.203	0.290	0.734	0.926*
		85-10A	28.611	28.626	0.142	0.201	0.387	0.409
WG 3A Short	Cu	85-6	19.796	19.790	0.140	0.162	0.360	0.363
		85-7	24.090	24.090	0.190	0.190	0.663	0.663
		85-8	33.351	33.351	0.209	0.209	0.333	0.333
		85-9	50.408	50.407	0.296	0.296	0.031	1.030*
		85-10A	28.596	28.596	0.155	0.155	0.371	0.371
WG 4A Sul.	Cu	85-6	19.851	19.851	0.149	0.149	0.262	0.262
		85-7	24.212	24.212	0.235	0.235	0.400	0.400
		85-8	33.363	33.363	0.172	0.172	0.311	0.310
		85-9	50.406	50.406	0.207	0.207	0.586	0.586
		85-10A	28.681	28.681	0.171	0.171	0.313	0.313
WG 4A Hyd.	Cu	85-6	19.890	19.888	0.082	0.118	0.217	0.221
		85-7	24.330	24.332	0.081	0.139	0.180	0.245*
		85-8	33.397	33.384	0.152	0.243	0.320	0.387
		85-9	50.530	50.524	0.135	0.156	0.605	0.595
		85-10A	28.716	28.716	0.096	0.096	0.212	0.212

* These data show large difference between 5% and 1% levels of significance.

Table 6

ISO/TC 183 Au, Ag and Cu in Copper Concentrates
Comparison between suspected outliers identified by Grubbs' and Dixon's tests
(1% Significance level)

WG	Element	Sample	Cochran	Grubbs	Dixon
WG 1A	Au	85-1	-	-	-
	Au	85-2	LAB 2 LAB 9	- -	- -
	Au	85-3	LAB30	-	-
	Au	85-4	LAB30	-	-
	Au	85-5	-	-	-
	Au	85-11	LAB30	-	-
WG 1A	Ag	85-5	-	-	-
	Ag	85-1	-	-	-
	Ag	85-4	LAB 9	-	-
	Ag	85-2	LAB14	-	-
	Ag	85-3	-	-	-
	Ag	85-11	-	-	-
WG 2A	Ag	85-1	-	-	-
	Ag	85-2	AU 3 CHN 2 CHN 3	AU 3 - -	AU 3 - -
	Ag	85-3	-	-	-
	Ag	85-4	AU 2	-	-
	Ag	85-5	-	-	-
	Ag	85-11	-	AU 3	-

Table 6 (Cont'd)

ISO/TC 183 Au, Ag and Cu in Copper Concentrates
Comparison between suspected outliers
identified by Grubbs' and Dixon's tests
(1% Significance level)

WG	Element	Sample	Cochran	Grubbs	Dixon
WG 3A Long	Cu	85-6	LAB 4	-	-
	Cu	85-7	LAB 5	-	-
	Cu	85-8	-	LAB 3	LAB 3
			-	LAB26	LAB26
	Cu	85-9	LAB17	-	-
	Cu	85-10A	-	-	-
WG 3A Short	Cu	85-6	LAB19	LAB19	LAB19
			LAB24	LAB24	-
	Cu	85-7	-	-	-
	Cu	85-8	-	LAB26	LAB26
	Cu	85-9	-	-	-
	Cu	85-10A	-	-	-
WG 4A Sul.	Cu	85-6	GER 3	-	-
	Cu	85-7	-	-	-
	Cu	85-8	CND 3	-	-
	Cu	85-9	GER 3	-	-
	Cu	85-10A	-	-	-
WG 4A Hyd.	Cu	85-6	CND 3	CND 4	CND 4
			CND 4	GER 5	-
			GER 5	-	-
	Cu	85-7	UK 1	CND 4	CND 4
	Cu	85-8	-	-	-
	Cu	85-9	-	-	-
	Cu	85-10A	CND 4	CND 4	CND 4

Table 7

ISO/TC 183 Au, Ag and Cu in Copper Concentrates
Comparison between suspected outliers identified by Grubbs' and Dixon's tests
(5% Significance level)

WG	Element	Sample	Cochran	Grubbs	Dixon
WG 1A	Au	85-1	-	-	-
	Au	85-2	LAB 2	LAB13	LAB13
			LAB 9	-	-
	Au	85-3	LAB30	-	-
	Au	85-4	LAB30	LAB32	LAB32
	Au	85-5	-	-	-
	Au	85-11	LAB30	-	-
	Ag	85-5	-	-	
	Ag	85-1	LAB 2	LAB 2	-
			LAB 3	-	-
	Ag	85-4	LAB 7	-	-
			LAB 9	-	-
	Ag	85-2	LAB14	LAB 8	LAB 8
	Ag	85-3	-	-	-
	Ag	85-11	LAB 8	-	-
WG 2A	Ag	85-1	-	-	-
	Ag	85-2	AU 2	AU 3	AU 3
			AU 3	-	-
			CHN 2	-	-
			CHN 3	-	-
	Ag	85-3	-	-	-
	Ag	85-4	AU 2	-	-
	Ag	85-5	-	-	AU 2
	Ag	85-11	-	AU 3	AU 3

Table 7 (cont'd)

ISO/TC 183 Au, Ag and Cu in Copper Concentrates
Comparison between suspected outliers
identified by Grubbs' and Dixon's tests
(5% Significance level)

WG	Element	Sample	Cochran	Grubbs	Dixon
WG 3A Long	Cu	85-6	LAB 4	-	-
	Cu	85-7	LAB 5	-	-
	Cu	85-8	-	LAB 3	LAB 3
			-	LAB26	LAB26
	Cu	85-9	LAB17	LAB26	LAB26
			LAB24	-	-
			LAB26	-	-
	Cu	85-10A	LAB24	-	-
			LAB26	-	-
WG 3A Short	Cu	85-6	LAB 4	LAB19	LAB19
			LAB19	LAB24	LAB24
			LAB24	-	-
	Cu	85-7	-	-	-
	Cu	85-8	-	LAB26	LAB26
	Cu	85-9	-	-	-
	Cu	85-10A	-	-	-
WG 4A Sul.	Cu	85-6	GER 3	-	-
	Cu	85-7	-	-	-
	Cu	85-8	CND 3	-	-
	Cu	85-9	GER 3	-	-
	Cu	85-10A	-	-	-

Table 7 (cont'd)

ISO/TC 183 Au, Ag and Cu in Copper Concentrates
Comparison between suspected outliers
identified by Grubbs' and Dixon's tests
(5% Significance level)

WG	Element	Sample	Cochran	Grubbs	Dixon
WG 4A Hyd.	Cu	85-6	CND 3	CND 4	CND 4
			CND 4	GER 5	GER 5
			GER 4	-	-
			GER 5	-	-
			UK 1	-	-
	Cu	85-7	AU 1	CND 4	CND 4
			GER 5	-	-
			JP 2	-	-
			UK 1	-	-
	Cu	85-8	CND 3	-	-
			CND 4	-	-
			GER 4	-	-
	Cu	85-9	CND 3	-	-
	Cu	85-10A	CND 4	CND 4	CND 4

Table 8

ISO/TC 183 Au, Ag and Cu in Copper Concentrates
Summary of the difference between Grubbs' and Dixon's tests

WG	Element	Sample	Cochran	Grubbs	Dixon
			1% Level of significance		
WG 2A	Ag	85-11	-	AU 3	-
WG 3A	Cu	85-6	LAB19	LAB19	LAB19
Short			LAB24	LAB24	-
WG 4A	Cu	85-6	CND 3	CND 4	CND 4
Hyd.			CND 4	GER 5	-
			GER 5	-	-
			5% Level of significance		
WG 1A	Ag	85-1	LAB 2	LAB 2	-
			LAB 3	-	-
WG 2A	Ag	85-5	-	-	AU 2

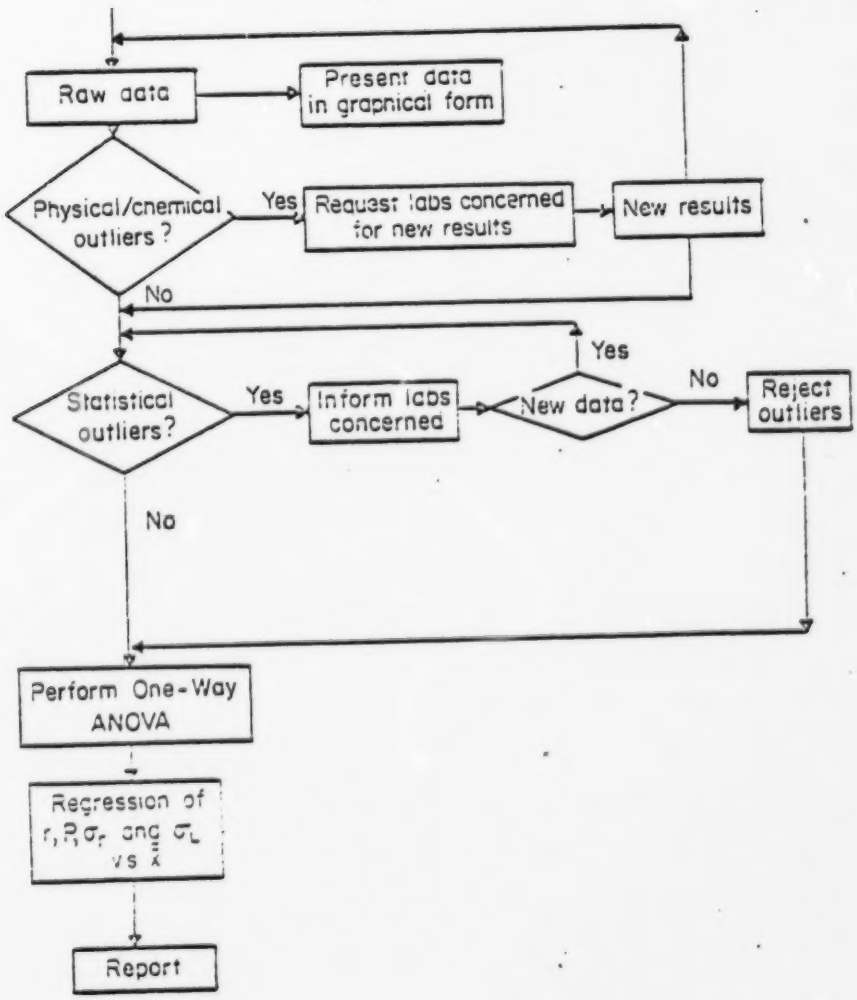

Figure 1. Flow Chart of the Procedure for Statistical Evaluation of Analytical Data Resulting from International Tests If The Test Sample is Known to be Homogeneous.

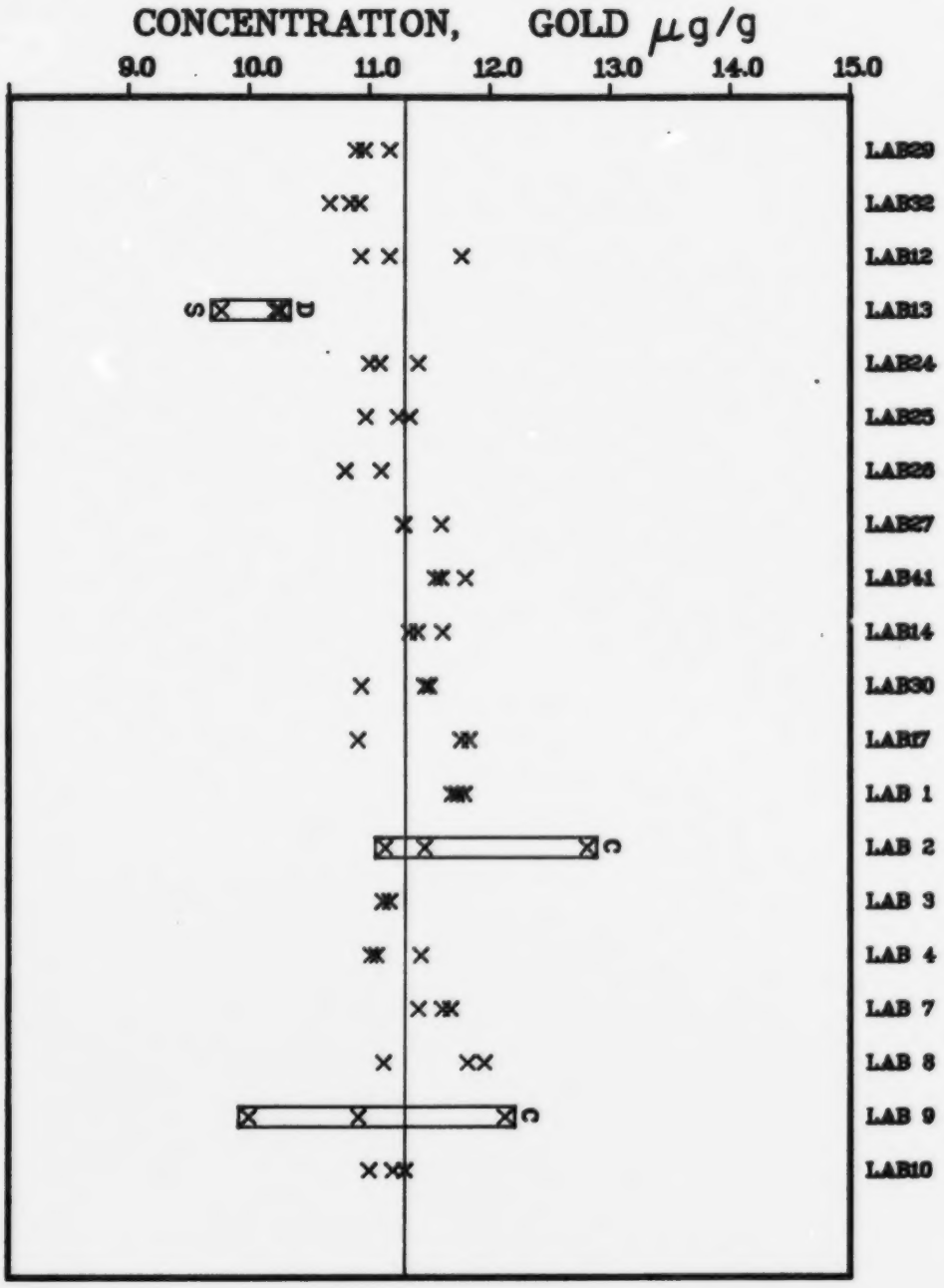

Figure 2.1
ISO/REC 163/WG 1A/WG 1A-3 AU AND AG IN COPPER CONC BY FIRE ASSAY - GOLD
SAMPLE 85-2

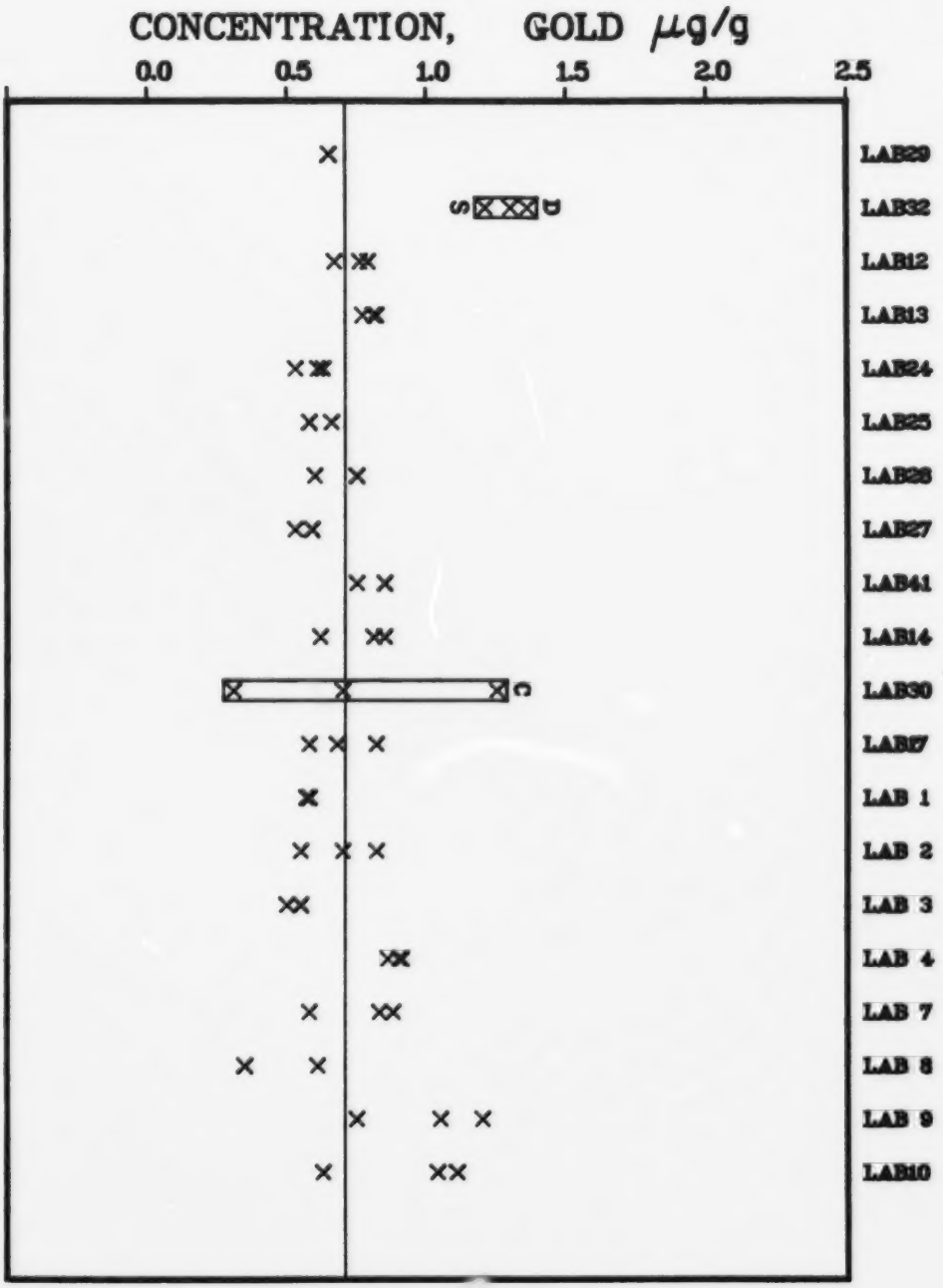

Figure 2.2
ISO/TC 153/WG 1A/WG 1A-3 AU AND AG IN COPPER CONC. BY FIRE ASSAY - GOLD
SAMPLE: 85-4

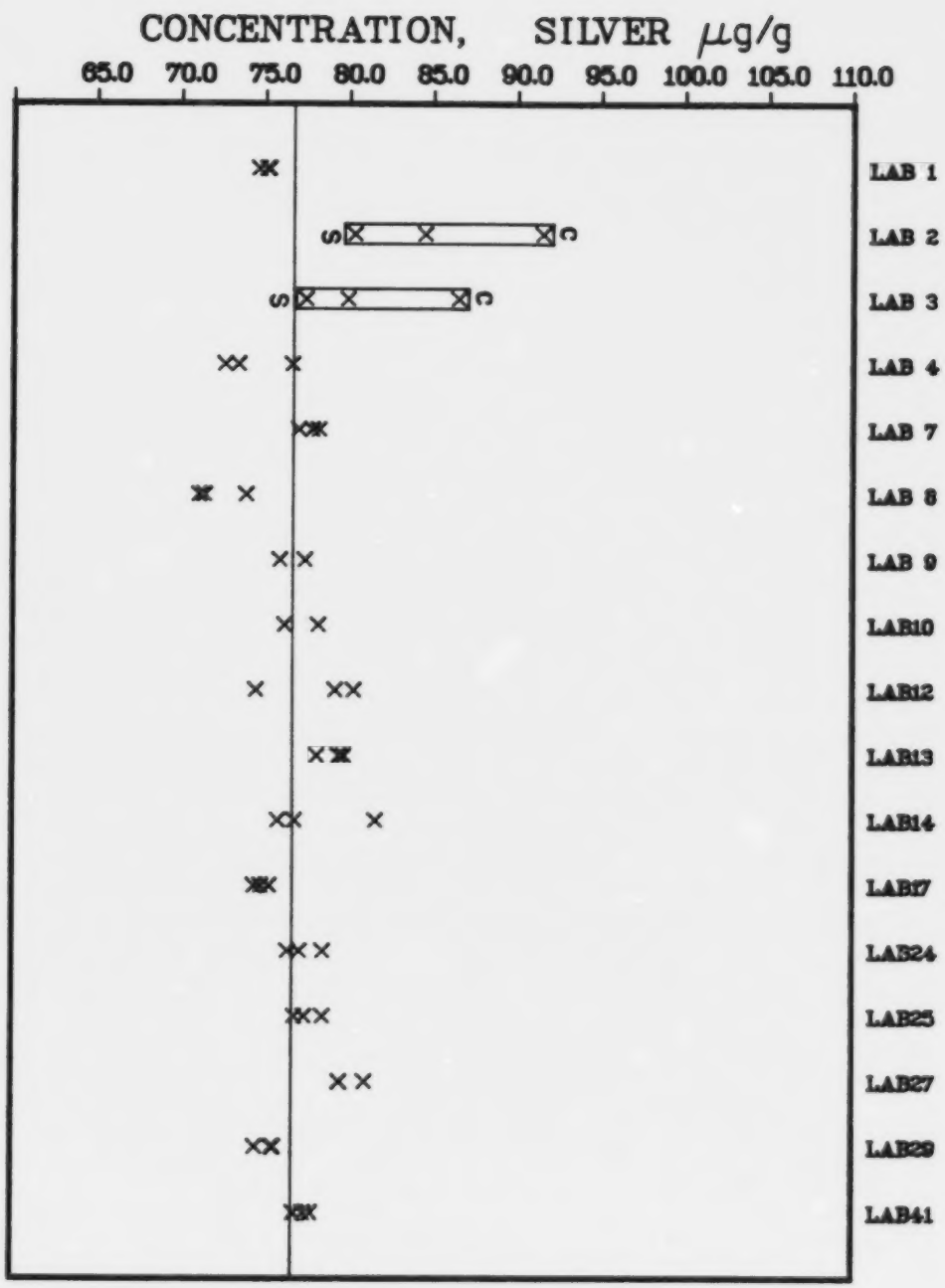

Figure 2.3
ISO/TC 183/WG 1A/WG 1A-3 AU AND AG IN COPPER CONC. BY FIRE ASSAY - SILVER
SAMPLE 85-1

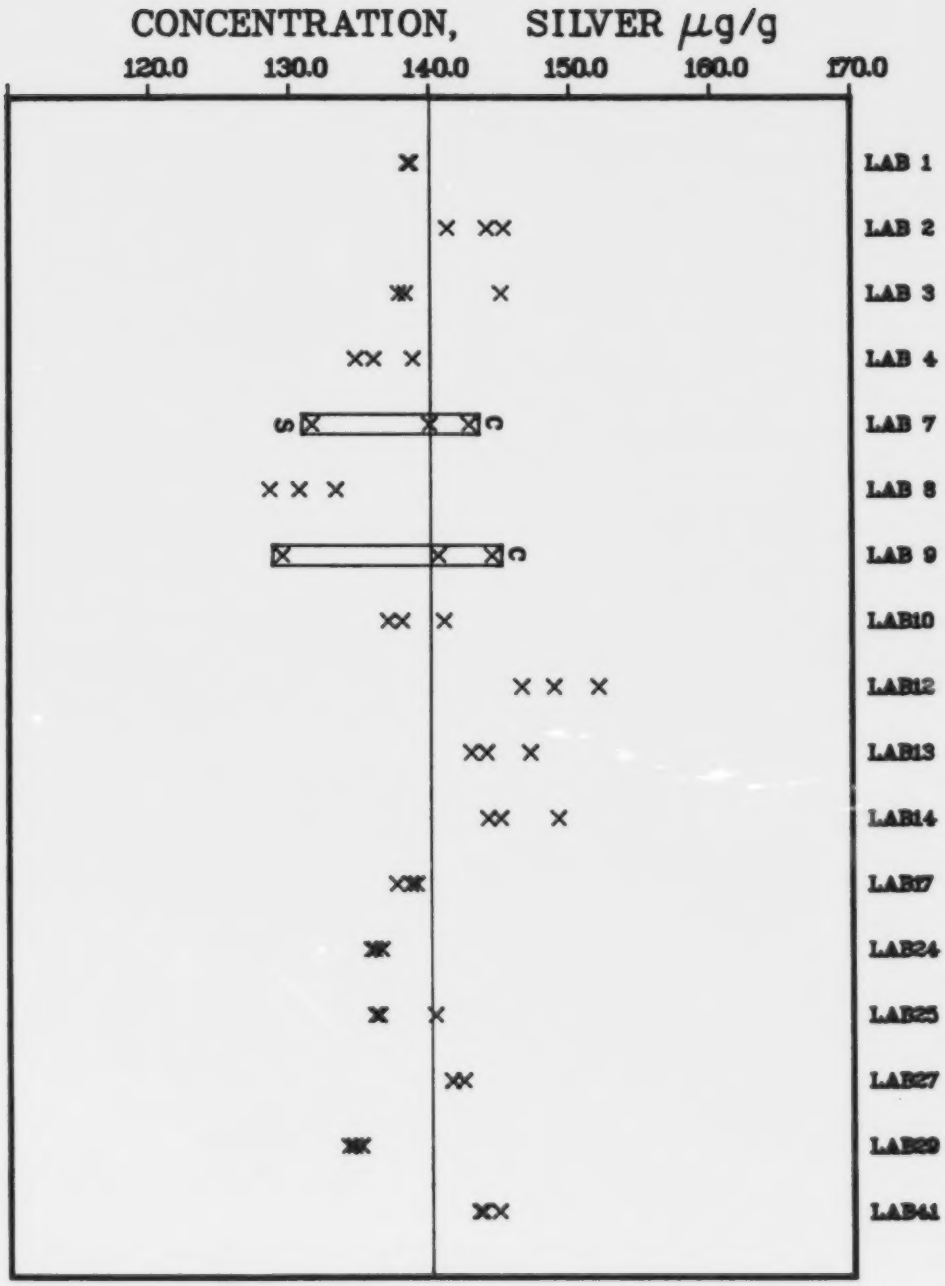

Figure 2.4
ISO/TC 183/WG 1A/WG 1A-3 AU AND AG IN COPPER CONC. BY FIRE ASSAY - SILVER
SAMPLE 85-4

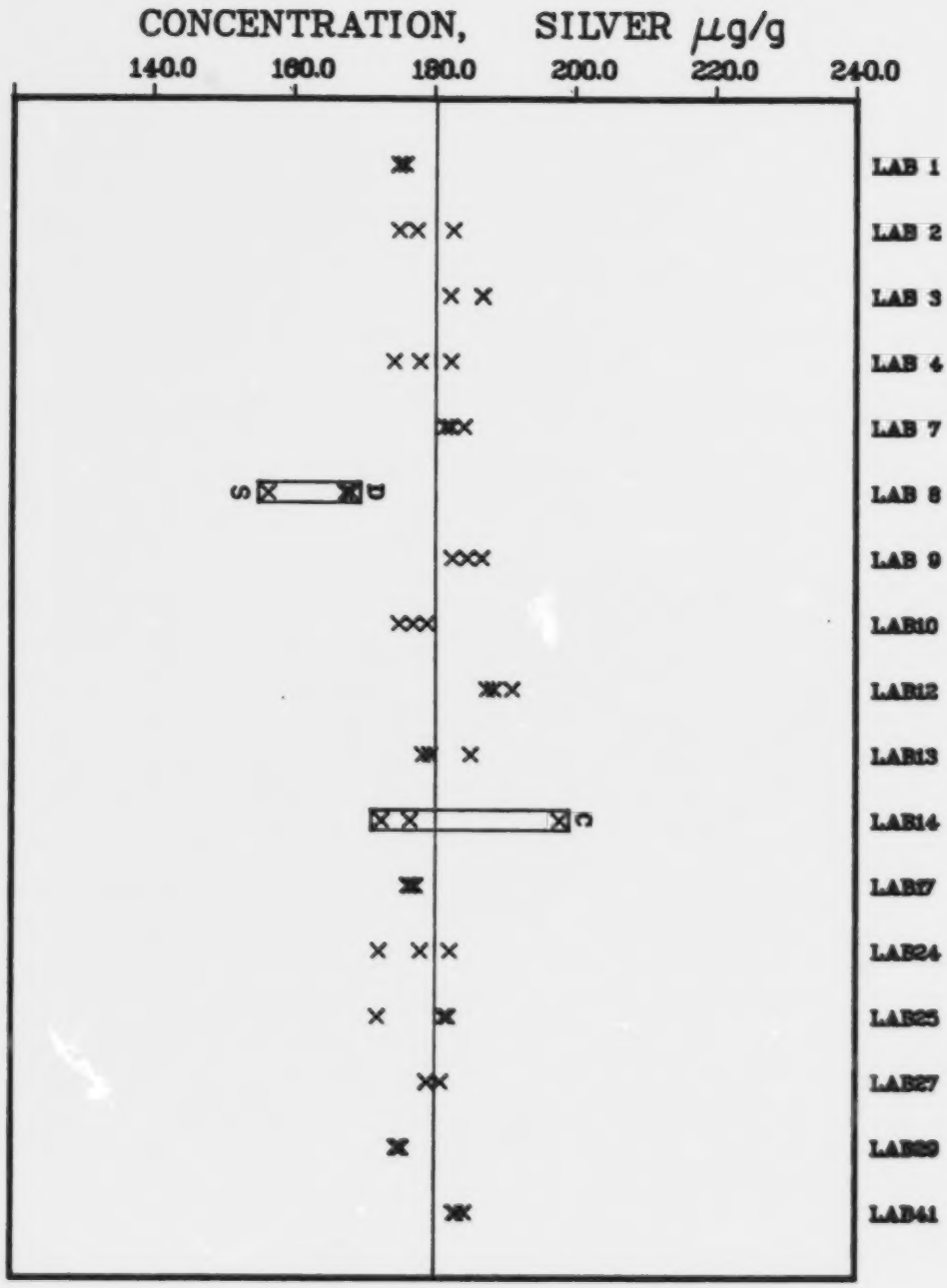

Figure 2.5
ISO/TC 183/WG 1A/WG 1A-3 AU AND AG IN COPPER CONC. BY FIRE ASSAY - SILVER
SAMPLE: 85-2

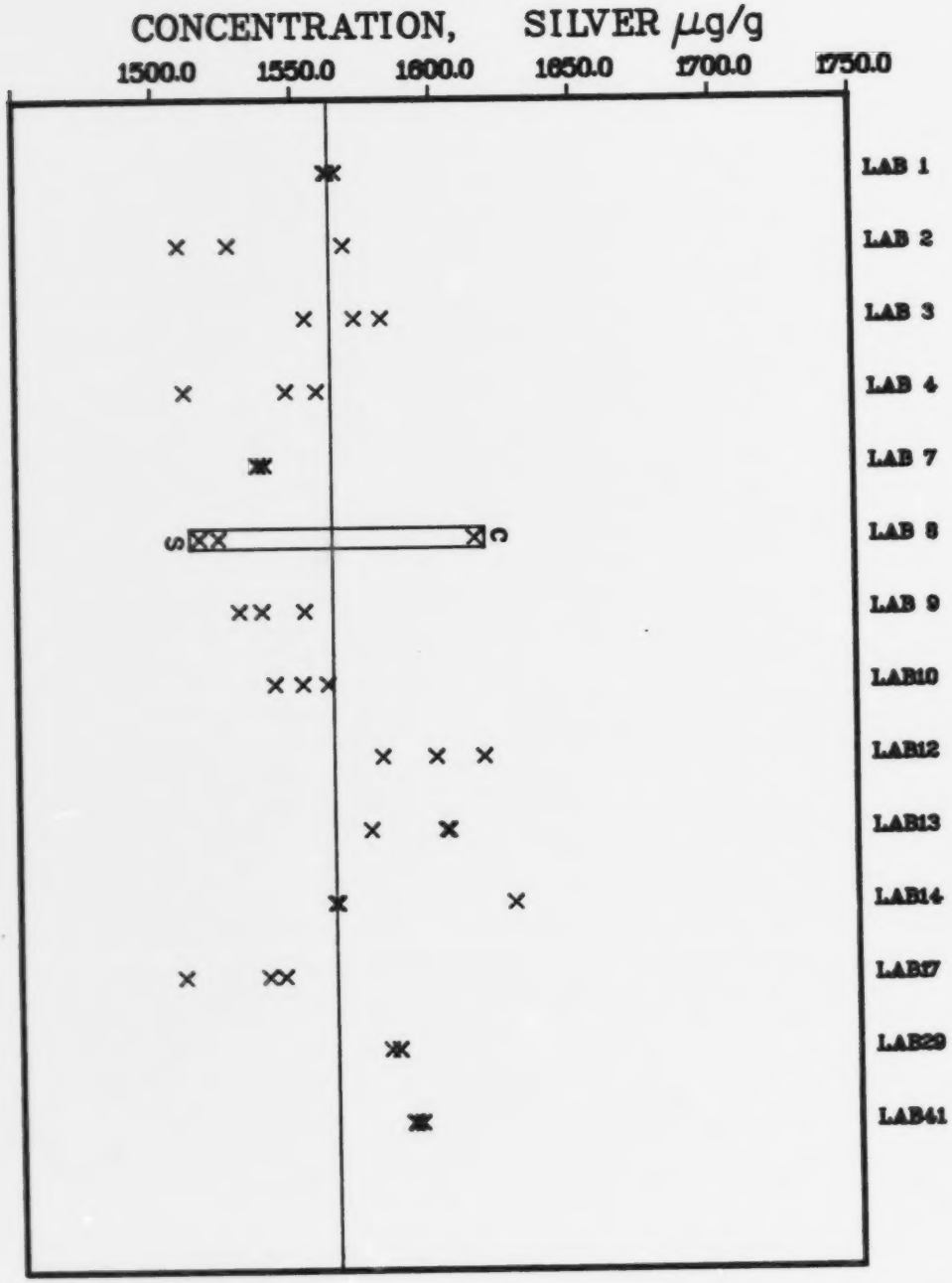

Figure 2.6
ISO/TC 183/WG 1A/WG 1A-3 AU AND AG IN COPPER CONC. BY FIRE ASSAY - SILVER
SAMPLE: 85-11

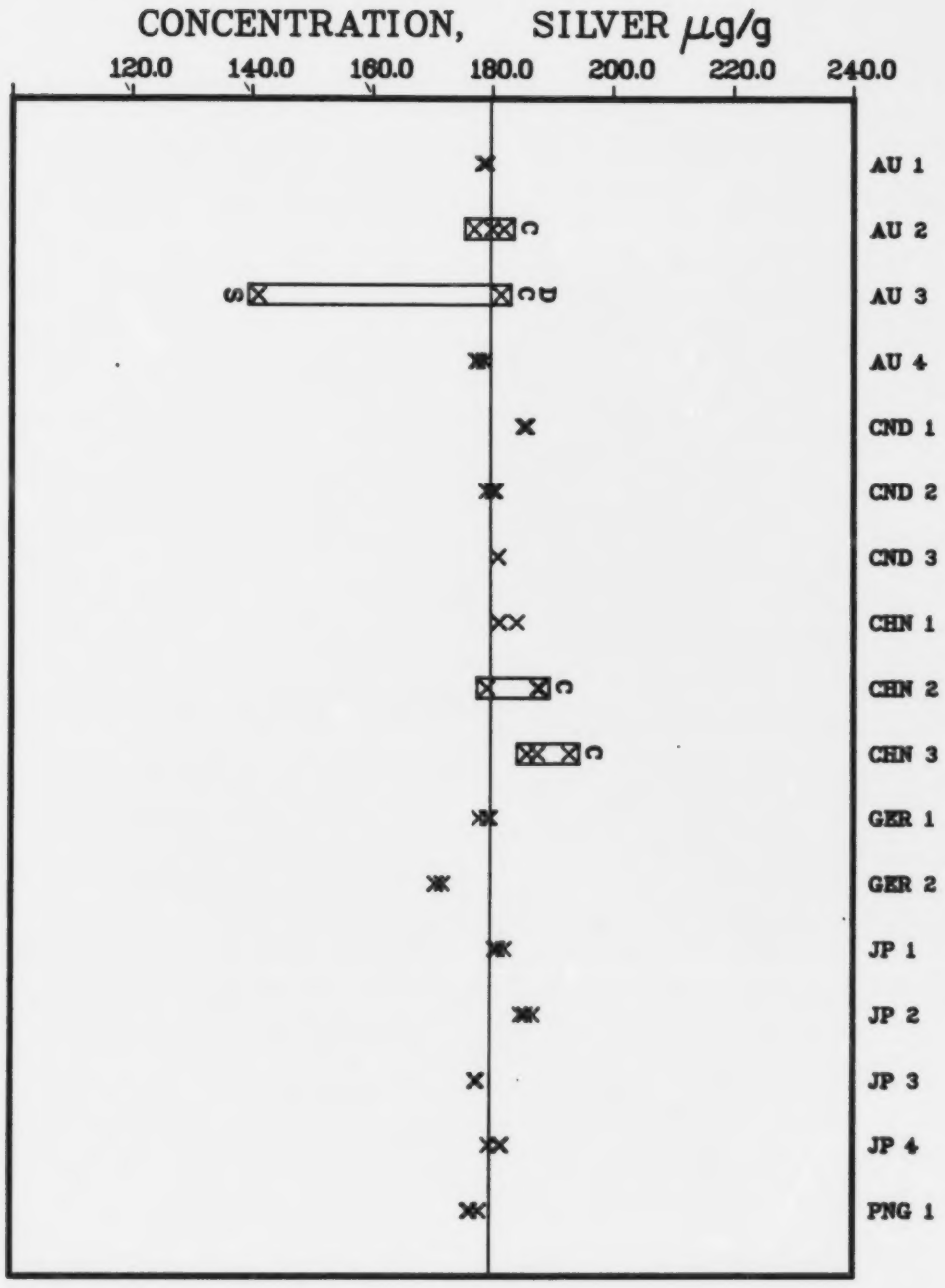

Figure 2.7
ISO/TC 183/WG 2A/WG 2A-3 SILVER IN COPPER CONC. BY FA-AAS METHOD
SAMPLE: 85-2

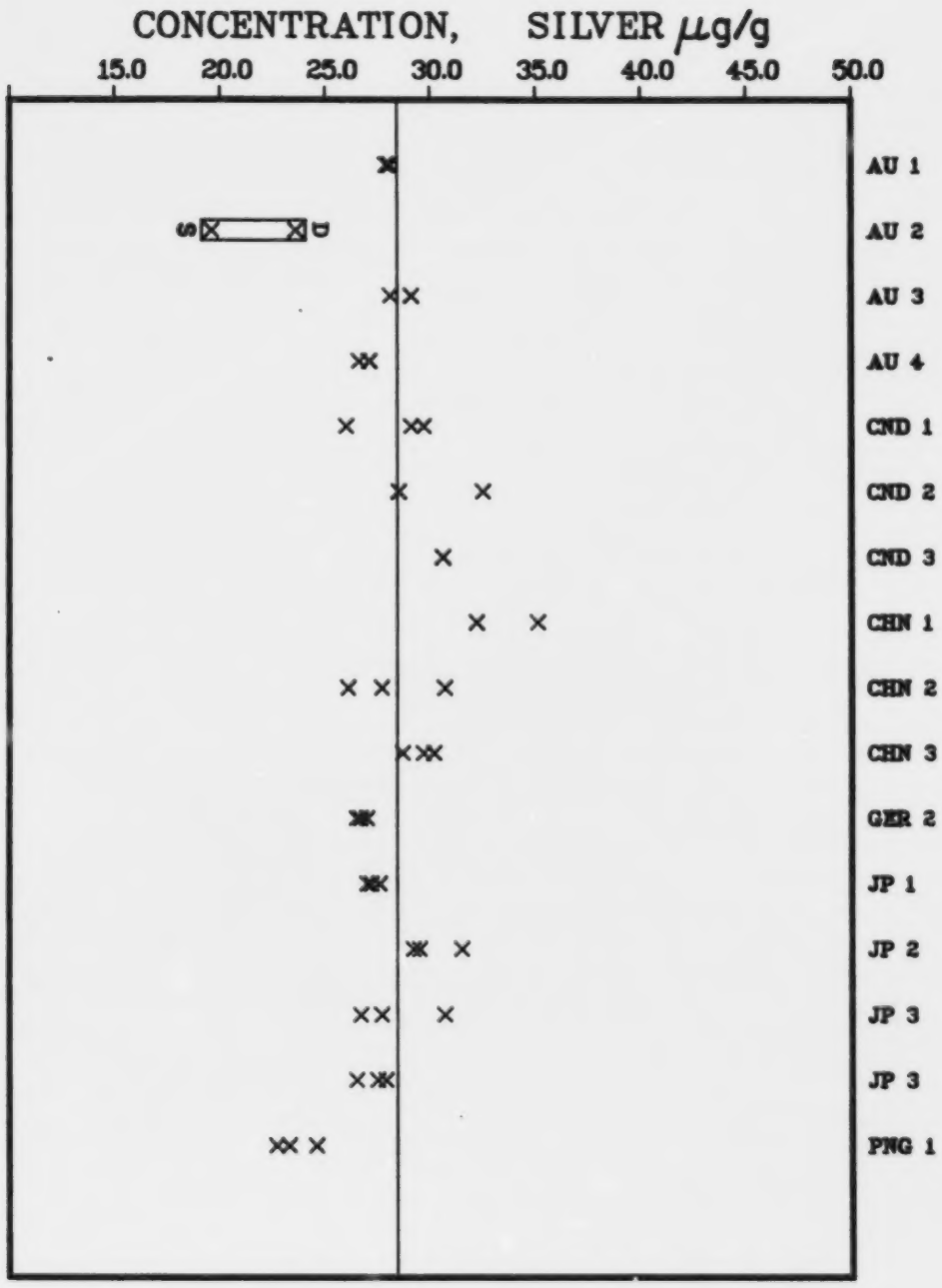

Figure 2.8
ISO/TC 183/WG 2A/WG 2A-3 SILVER IN COPPER CONC. BY FA-AAS METHOD
SAMPLE 85-5

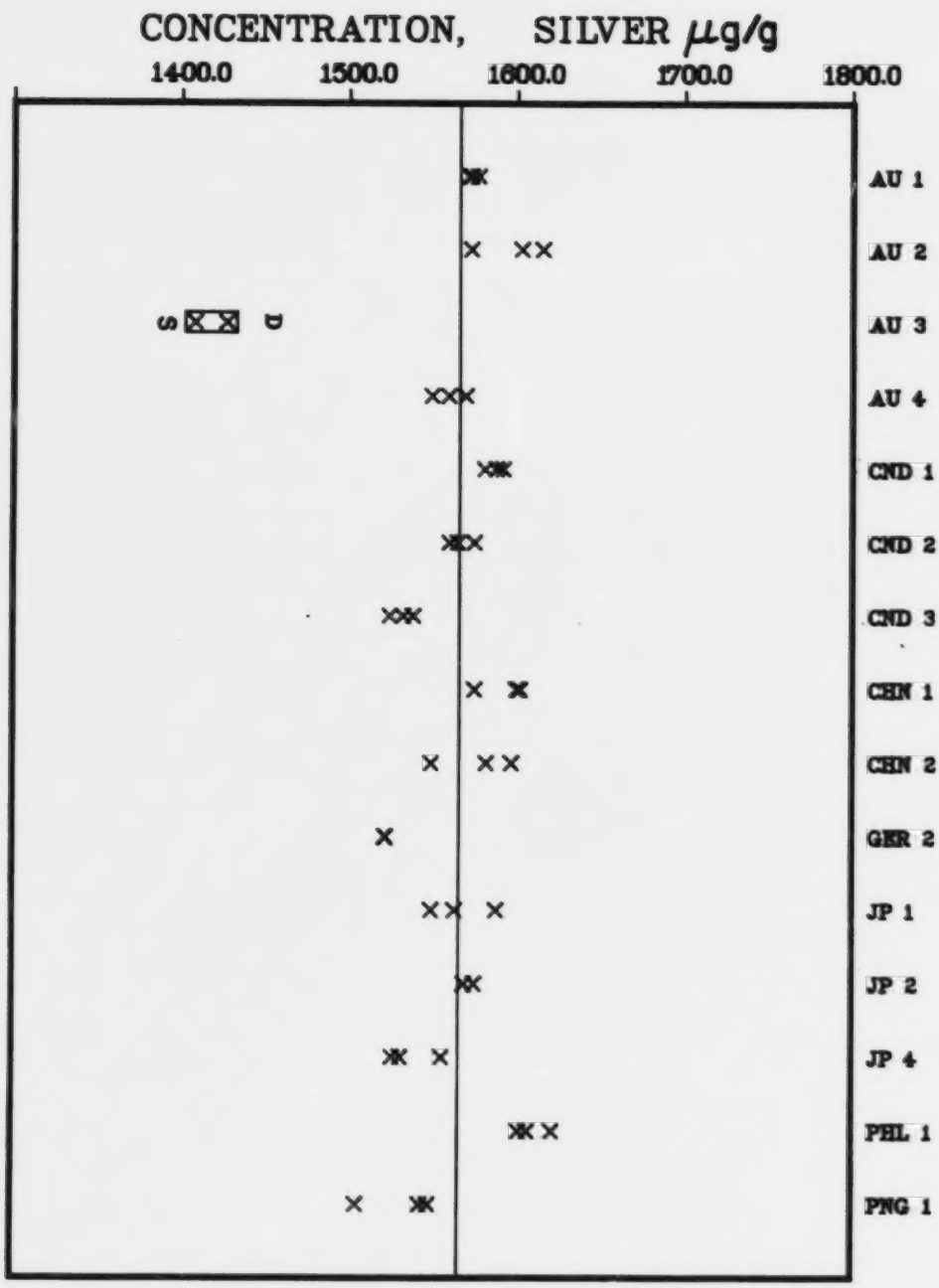

Figure 2.9
ISO/TC 183/WG 2A/WG 2A-3 SILVER IN COPPER CONC. BY FA-AAS METHOD
SAMPLE: 85-11

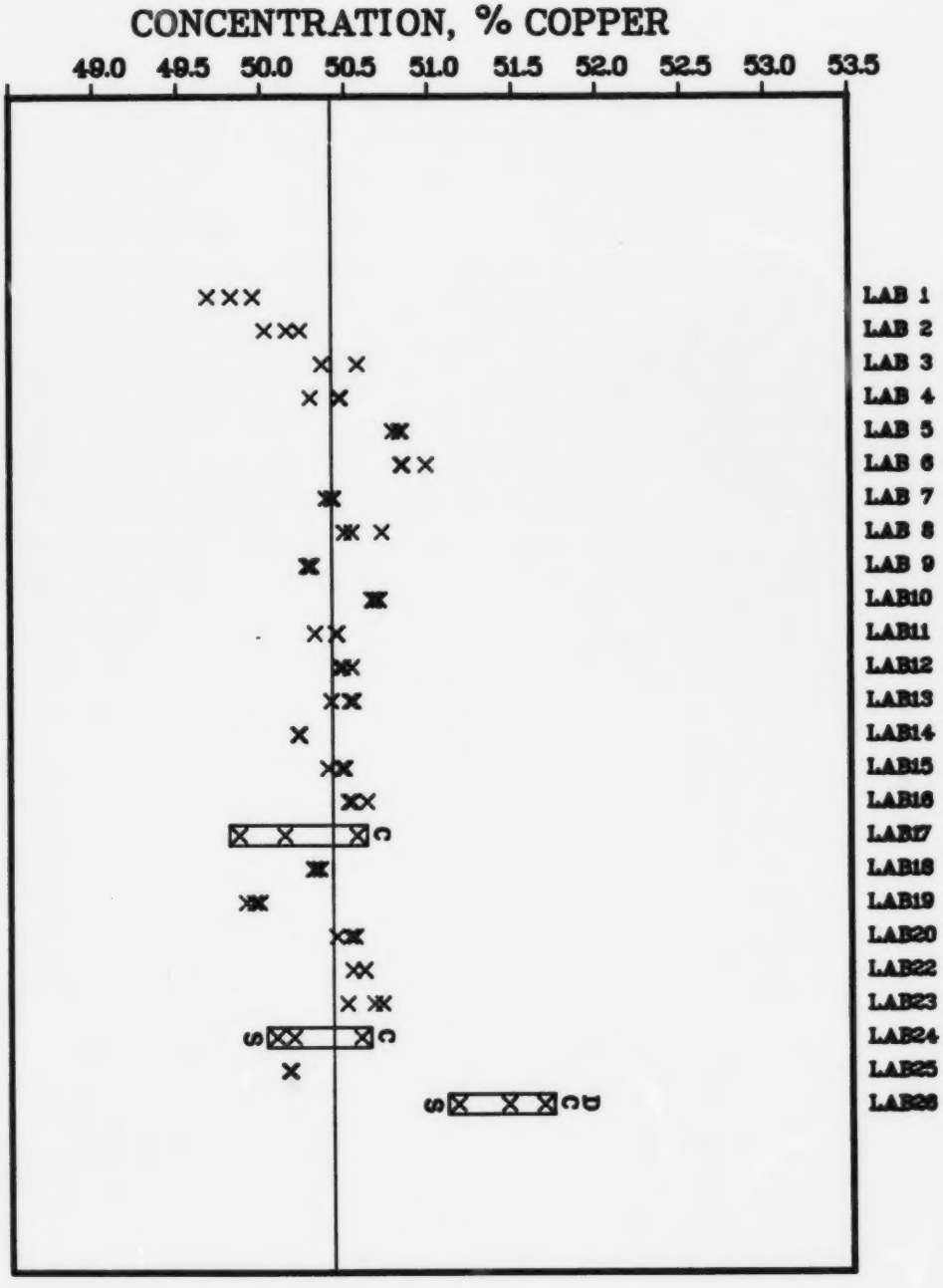

Figure 2.10

ISO/TC 183/WG 3A/WG 3A-9 COPPER IN COPPER CONC. LONG IODIDE METHOD

SAMPLE 85-9

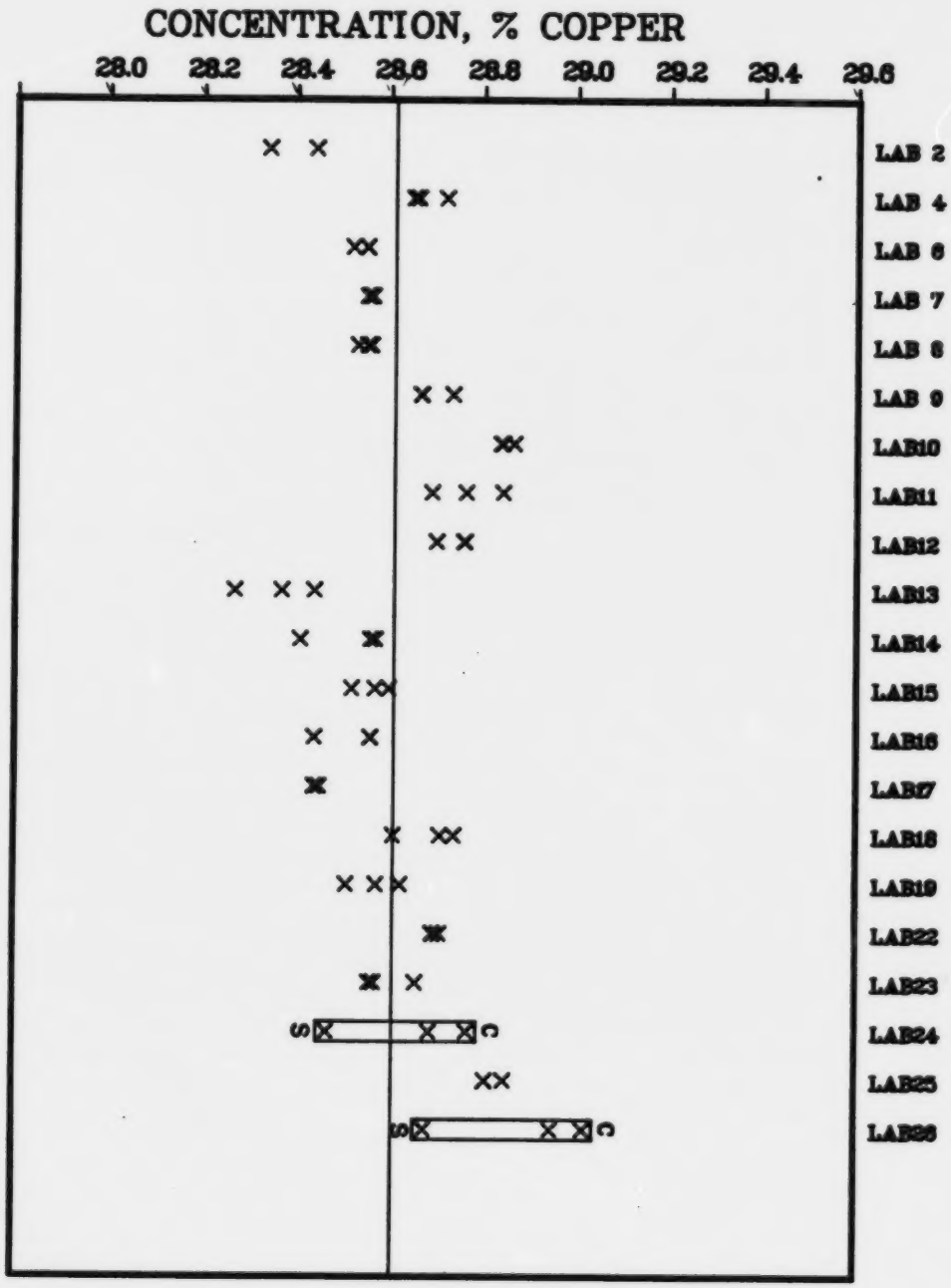

Figure 2.11

ISO/TC 183/WG 3A/WG 3A-6 COPPER IN COPPER CONC. LONG IODIDE METHOD

SAMPLE 85-10A

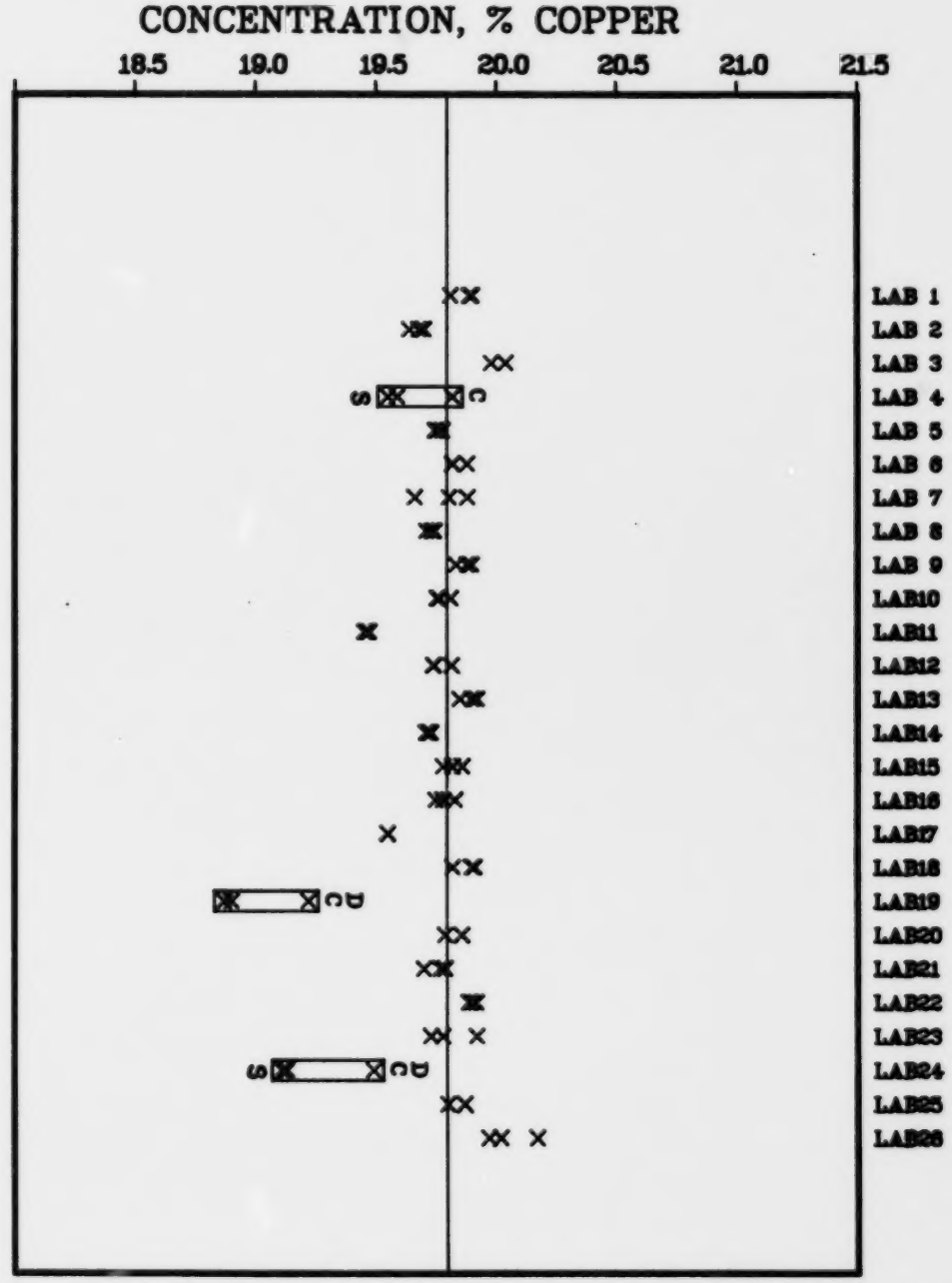

Figure 2.12
ISO/TC 183/WG 3A/WG 3A-5 COPPER IN COPPER CONC. SHORT IODIDE METHOD
SAMPLE 85-8

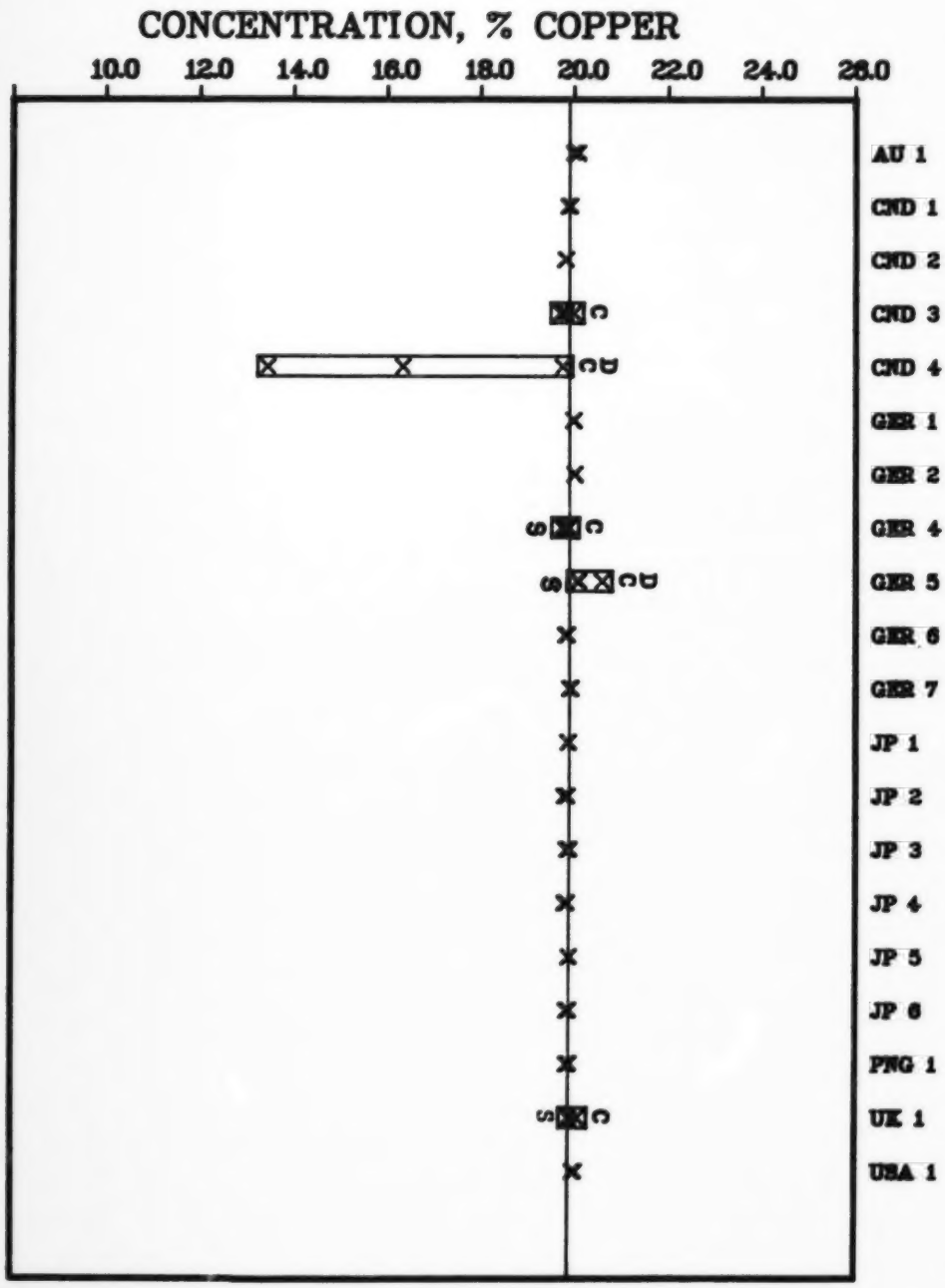

Figure 2.13
ISO/TC 183/WG 4A/WG 4A-2 COPPER IN COPPER CONC. - ELECTROGRAVIMETRIC/HYDROXIDE
SAMPLE 85-6

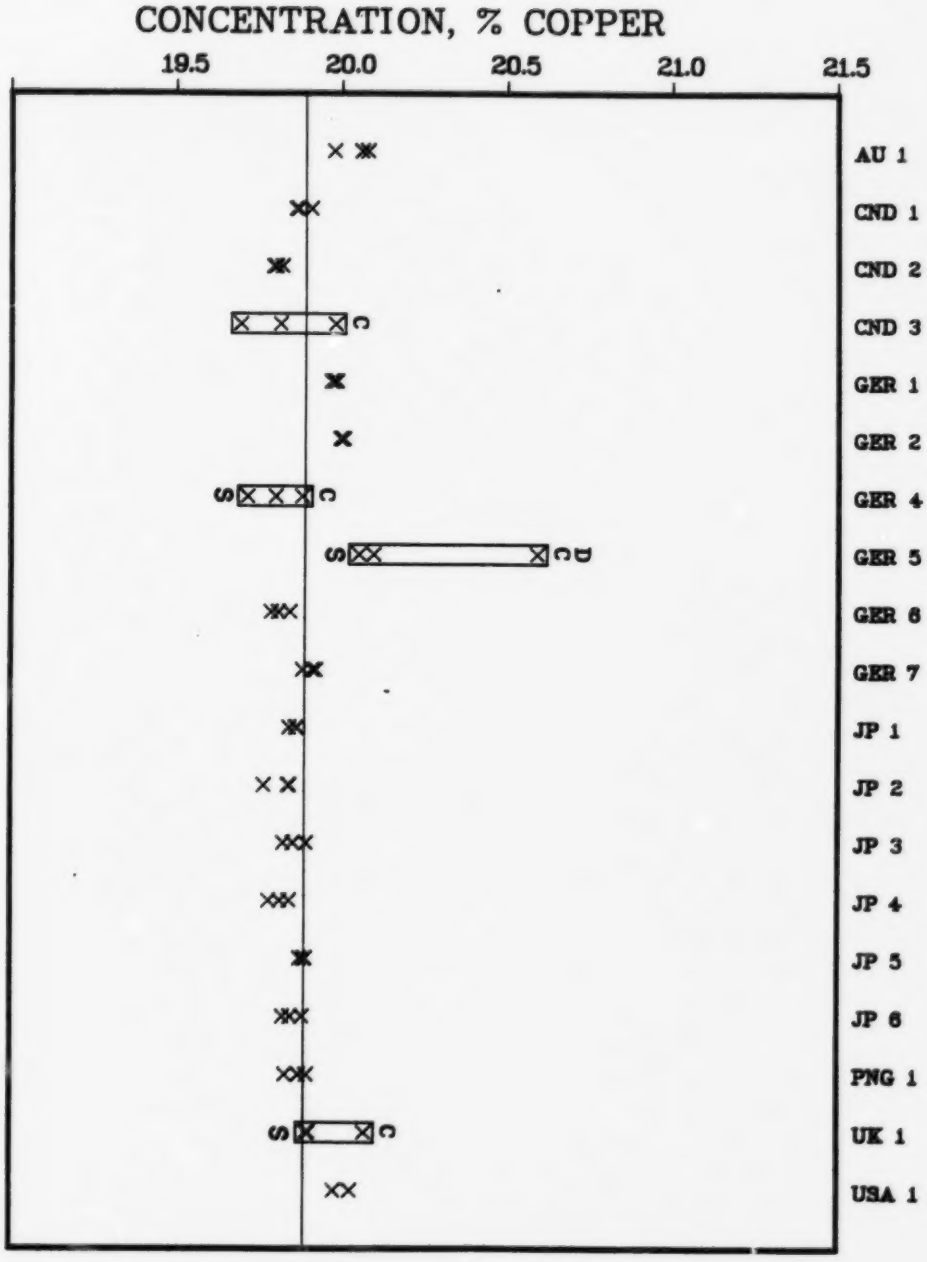

Figure 2.13A

ISO/TC 183/WG 4A/WG 4A-2 COPPER IN COPPER CONC. - ELECTROGRAVIMETRIC/HYDROXIDE

SAMPLE: 85-6

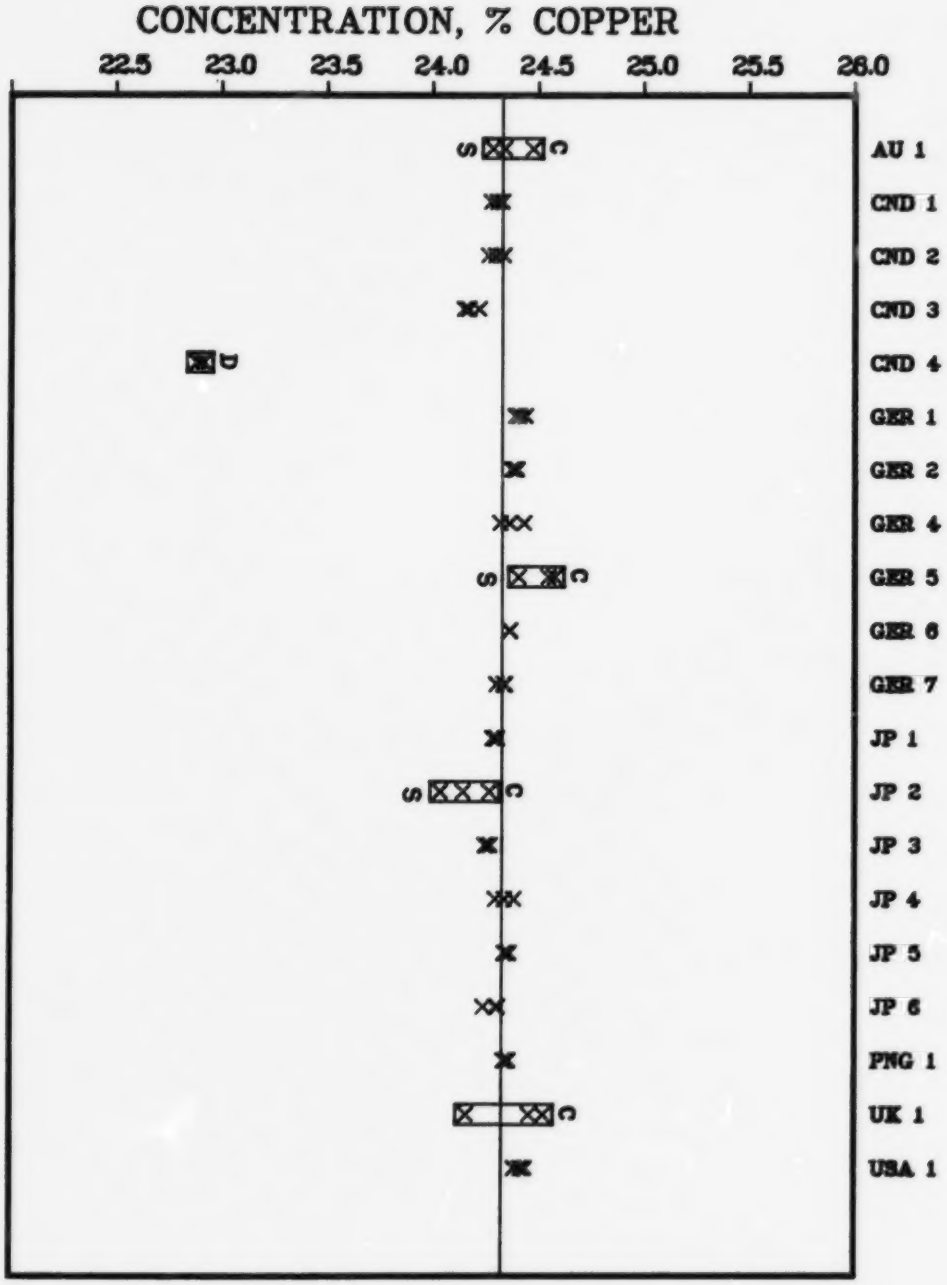

Figure 2.14
ISO/TC 183/WG 4A/WG 4A-2 COPPER IN COPPER CONC. - ELECTROGRAVIMETRIC/HYDROXIDE
SAMPLE 85-7

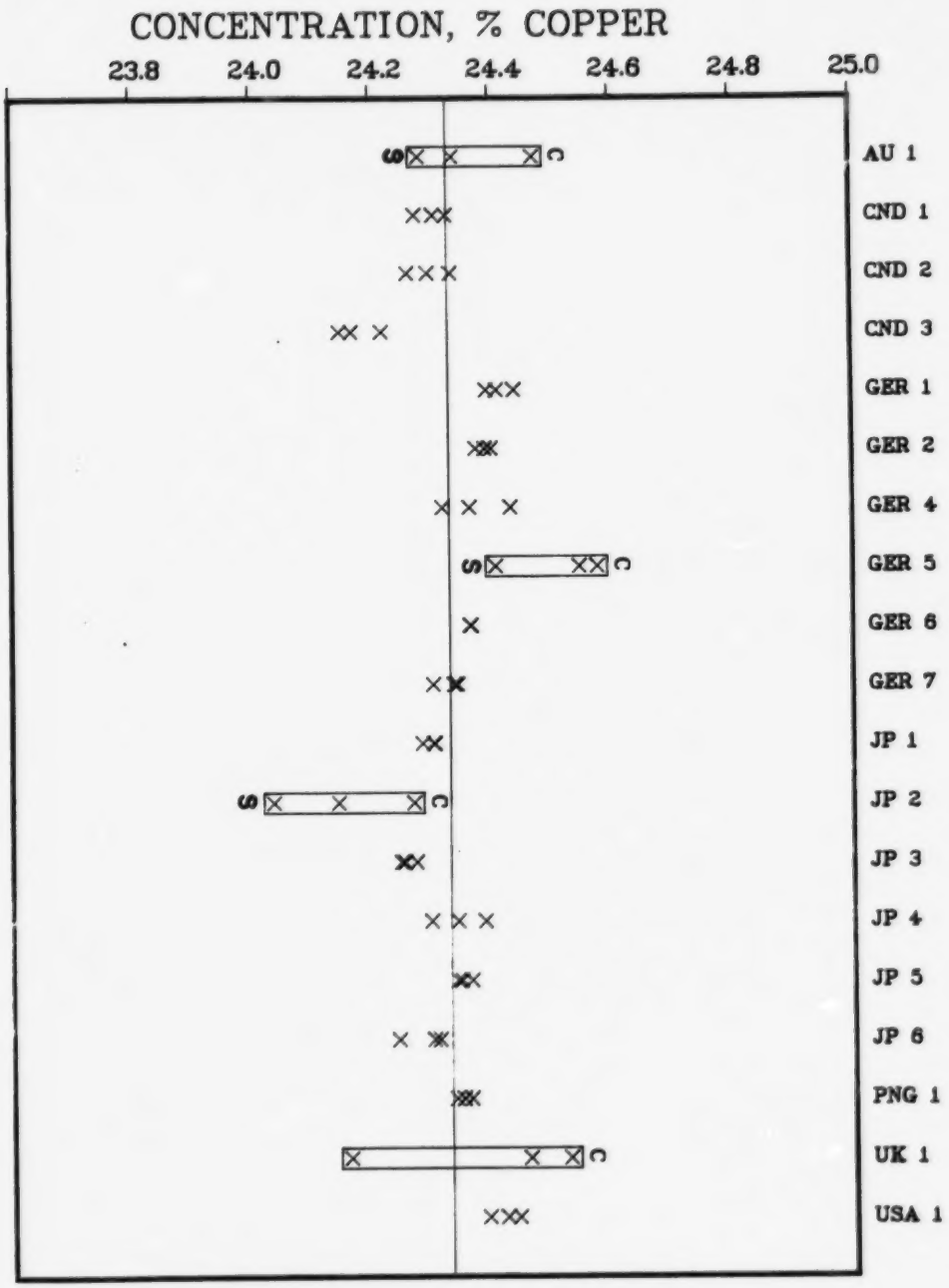

Figure 2.14A

ISO/TC 183/WG 4A/WG 4A-2 COPPER IN COPPER CONC. - ELECTROGRAVIMETRIC/HYDROXIDE

SAMPLE: 85-7

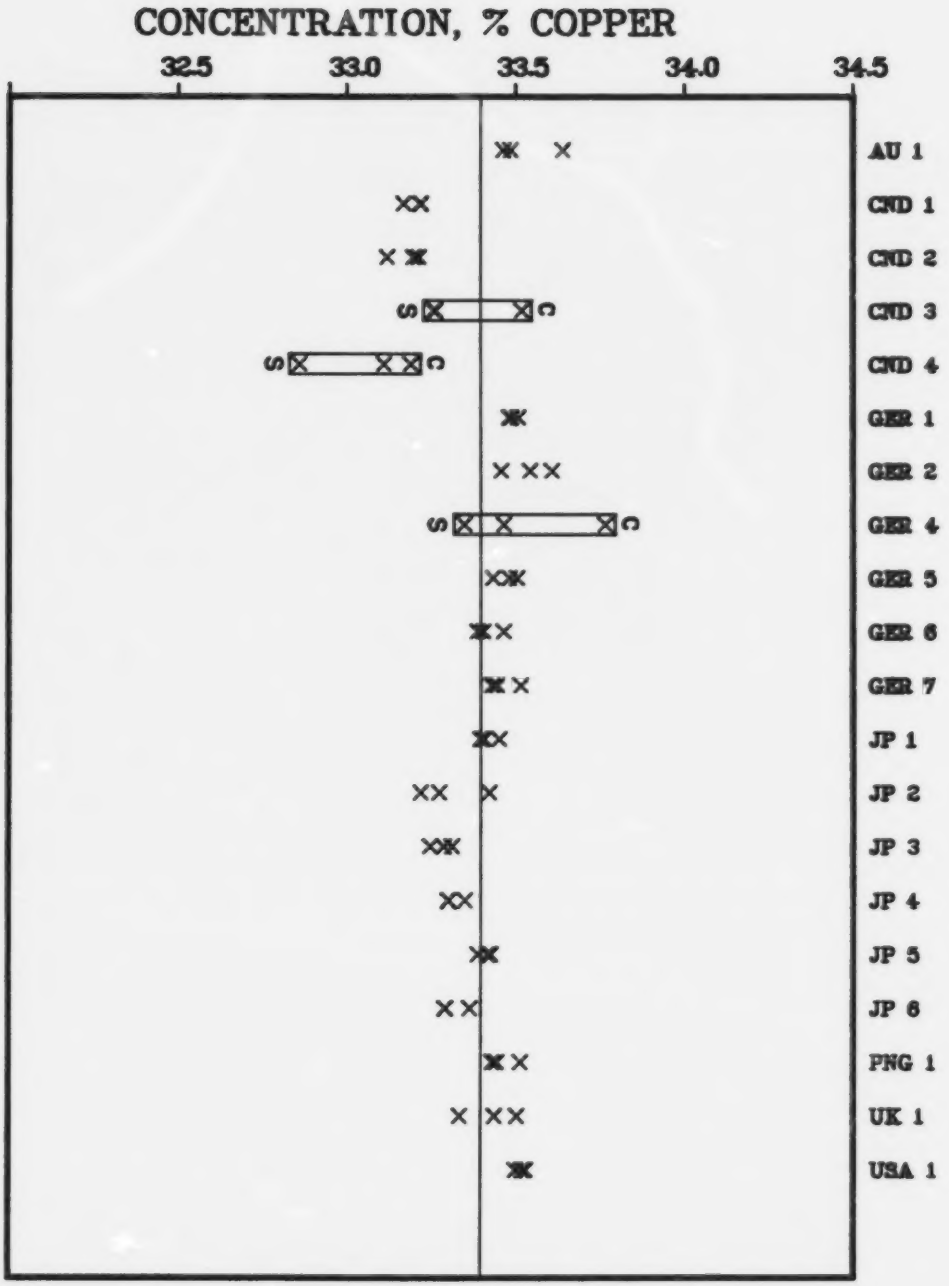

Figure 2.15
ISO/TC 183/WG 4A/WG 4A-2 COPPER IN COPPER CONC. - ELECTROGRAVIMETRIC/HYDROXIDE
SAMPLE: 85-8

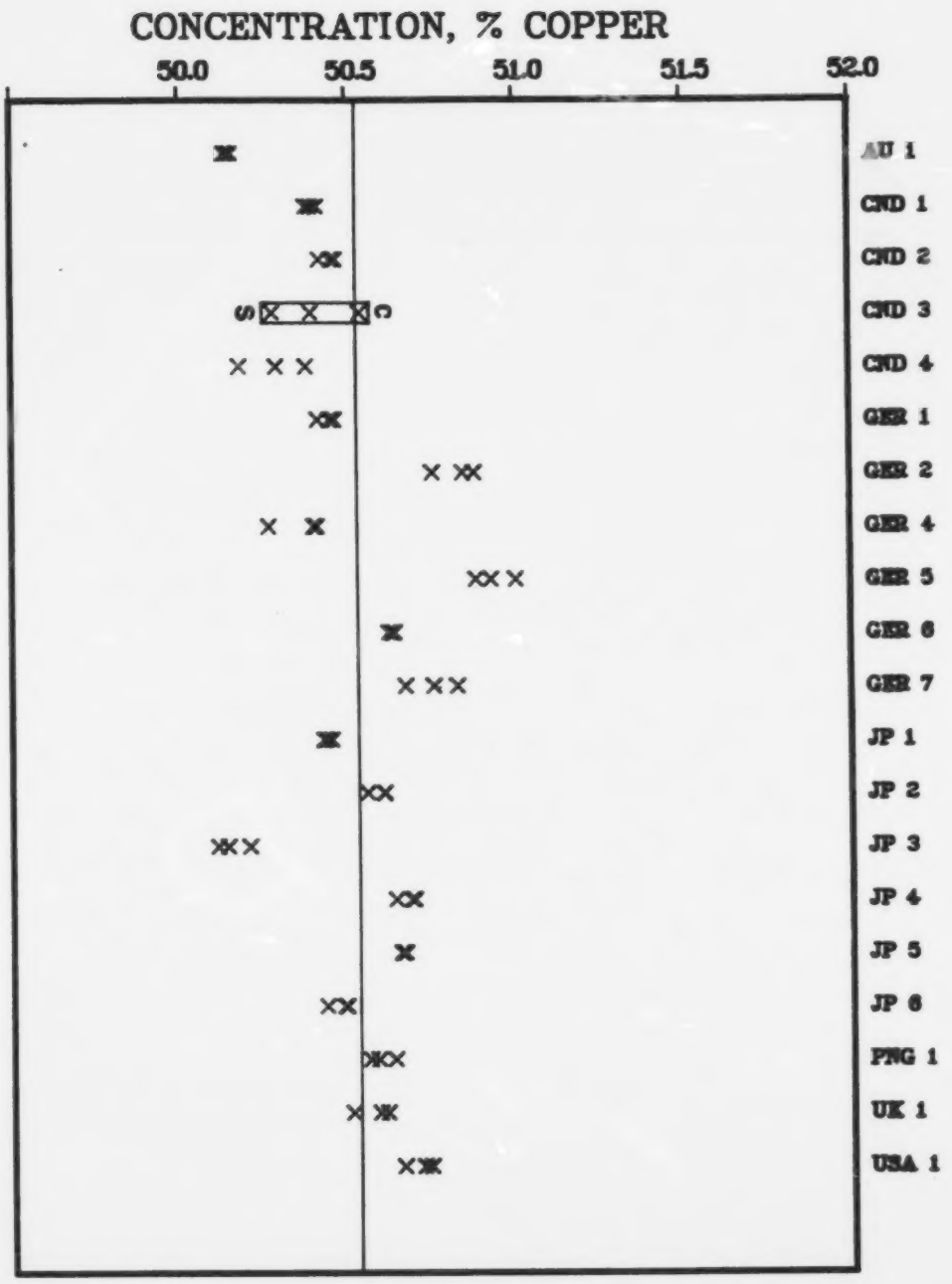

Figure 2.16

ISO/TC 183/WG 4A/WG 4A-2 COPPER IN COPPER CONC - ELECTROGRAVIMETRIC/HYDROXIDE

SAMPLE 85-9